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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Airframe
and
Engine Accessories

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of Airframe and Engine Accessories

LUBRICATION of airframe components and of engine accessories, as distinguished from lubrication of aircraft engines, is a field which has been the scene of rapid progress during the past few years. From war-created and accelerated demands, as well as from advances in civil aviation during the immediate pre-war and war-time periods, have arisen many developments in improved lubricants, as well as a better understanding of the fundamentals of aircraft lubrication. These developments promise benefits to aircraft operators through improved performance, lower maintenance costs, and reduction in the number of products required.

WARTIME flying gave impetus to many developments in aviation. The "impossible" was often accomplished. This applied particularly to lubrication of airframe mechanisms when stratosphere flying and desert ground conditions had to be encountered in the same flight. The developments which resulted from military exigencies are available today to aircraft designers and users. This article presents these developments in the interest of dependable flight operation.

Only a few years ago, lubrication of airframe components and engine accessories presented few, if any, difficult problems. The slow-flying aircraft then in use, with their wood and fabric construction, were adequately serviced at a few points, such as wheel bearings and magneto bearings, with automotive greases or anti-friction bearing lubricants developed for stationary machinery application. Control systems, consisting largely of lever, cable and pulley arrangements, required little or no lubrication due to the simplicity and light loading of the parts and the large clearances used.

In contrast to this picture, with the advent of all-metal, high-performance airplanes operating at increasingly high altitudes and in all parts of the earth from Equatorial zones to the Arctic Circle, the need arose for improved types of aircraft lubricants, capable of providing satisfactory operation of highly-stressed precision mechanisms under all of the adverse conditions that might arise. For example, operating conditions of military aircraft became unusually severe, calling for satisfactory performance at temperatures as low as −65°F. and as high as 175°F. under summer desert conditions.

Meanwhile operating speeds and loads of bearings and of such devices as screw actuators were being increased in the continuous battle against weight, requiring lubricants with E.P. qualities and at the same time with minimum starting torque at low temperatures.

Aircraft hydraulic systems, which originally operated only the brakes, were called upon to retract the gear, to operate flaps, gun turrets, bomb-bay doors, together with a host of other equipment, and finally, in the guise of servo-mechanisms connected to the auto pilot, to fly the airplane itself.

To meet such conditions, and others as discussed later, an entirely new set of lubricants had to be developed. The story of the development of some

Courtesy Lockheed Aircraft Corp.

Fig. 1—The Lockheed "Constellation".

of these products has been reported previously.* The present article presents the application of these interesting developments to airframe lubrication, with additional information on later improvements that have occurred since publication of the earlier articles.

Application of these developments, in the form of improved lubricants and better lubrication practices, will provide ultimate benefits to aircraft designers and operators through greater dependability of operation.

AIRCRAFT GREASES

Currently used aircraft greases may be classified into four different types:

1 — General purpose.
2 — Low temperature.
3 — High temperature.
4 — Graphited greases.

The periodic lubrication requirements of most aircraft can be handled by only one lubricant, general purpose grease, which represents a major step in simplification of products. Some few models may still require a low temperature grease for periodic lubrication, although the trend is away from this.

During major overhaul, many aircraft can be serviced adequately with general purpose grease, high temperature grease, and usually a graphite grease. Others, especially those exposed to extremely low temperatures on the ground or at high altitudes, will require one or more kinds of low temperature grease.

General Purpose Grease

One of the latest and most useful types of greases developed from the commercial operator's viewpoint is the general purpose grease described by ANA** Specification AN-G-15. Its development centered around the requirements of various accessories, propellers, wheel bearings and for miscellaneous pressure gun fittings, such as on landing gear. This grease has moderately good low temperature properties and may be used down to minus 40°F. where minimum drag is a factor, or as low as minus 65°F. where enough starting torque is available. It is now being used for the lubrication of bearings in starters, dynamotors, inverters, actuator motors, landing gear retraction motors, magneto gears, booster pumps and wheel bearings. The general purpose grease is being used by one propeller manufacturer for hub lubrication and by all manufacturers of helicopters for the lubrication of rotor assemblies.

*"Low Temperature Grease Research," Lubrication, January 1944. "Lubrication Progress Paces Ball and Roller Bearings Developments," Lubrication, February 1945. "Greases, Part II," Characteristics and Uses," Lubrication, August 1945. "Military Aircraft Grease Lubrication," Maj. S. C. Britton and Dr. W. Schlesinger, S.A.E. Journal, June 1945.

**Army-Navy Aeronautical

The general purpose grease was tested by the Army in control systems of aircraft stationed in Alaska during the past winter. Pending conclusions from these tests, it is impossible to state whether the AN-G-15 grease will meet the low temperature requirements of Army aircraft. Since the operating conditions of commercial aircraft are not as severe as those of Army aircraft, the AN-G-15 grease can be used in a majority of the control systems of commercial models. Reflecting this trend, some of the major airframe manufacturers are now recommending this type of grease for such control systems.

In addition to the moderately good low temperature properties, the AN-G-15 grease has two other very desirable characteristics: first, it will not liquefy or thin out in a gear box and, second, it will stand up at high temperatures, as demonstrated by passing an endurance test requirement of 1,000 hours minimum in a high speed ball bearing at 10,000 RPM and 250°F.

The AN-G-15 grease comes the closest thus far to becoming the universal grease for commercial aircraft. It provides dependable lubrication over a wide temperature range, with obvious advantages in elimination of superfluous lubricants and the possibility of using the wrong product.

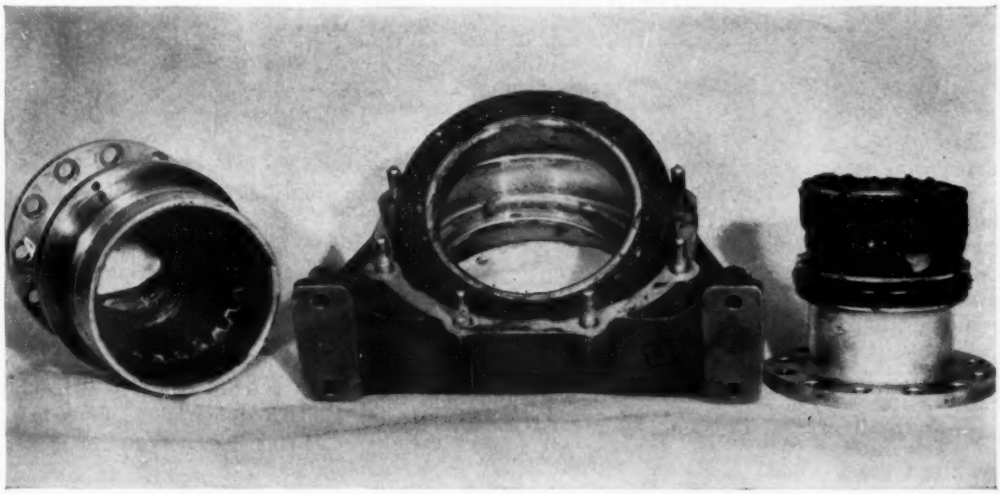
Low Temperature Greases

There are three types of low temperature greases, AN-G-3a, AN-G-25 and AN-G-10. AN-G-3a grease is intended for the lubrication of anti-friction bearings and other parts of the control system where the minimum drag at low temperature is vitally important. This grease will not stand up at moderately high temperatures, even though it has a high melting point, because of the tendency to evaporate or dry out, and should be limited to those parts operating under 175°F. The AN-G-3a specification, furthermore, has no provision for testing the working-down tendencies of greases meeting the specification and there is no guarantee, therefore, that some of them will not liquefy in gear boxes or high speed bearings at ordinary temperatures.

A new AN-G-25 specification will be released shortly covering a new low temperature, low evaporation, synthetic grease. The purpose of this grease is to overcome the shortcomings of AN-G-3a greases. The AN-G-25 type of grease is made from a synthetic oil. It has substantially the same low temperature properties of the AN-G-3a type but shows less than one-tenth the evaporation characteristics, according to laboratory tests. Another remarkable feature of the synthetic grease is its ability to stand up in a high speed ballbearing endurance test for 1,000 hours minimum at 250°F., and for 10,000 RPM. It will also stand temperatures up to 300°F. for short periods. Another feature of this grease is its stability against thinning out or working-down at high shear rates, as in a gear box.

Such synthetic greases may cause swelling of certain types of rubber. Buna N type of rubber is one of those found satisfactory with grease of this type.

The AN-G-10 grease is a low temperature extreme pressure type, being essentially an AN-G-3a grease with an EP additive. The AN-G-10 specification was prepared to satisfy the conditions found in some actuator gears and retracting screw jacks. AN-G-10 greases have the same good low temperature properties as other low temperature greases, although they are inclined to dry out or evaporate at moderately high temperatures, and some of them



Courtesy Allison Division, General Motors Corp.

Fig. 2—Condition of AN-G-15 grease after endurance test in propeller drive shaft bearing and splines as used in extension shaft installations in the Bell P-63 and Douglas B-42 airplanes. Note ample supply of grease remaining on bearing surfaces and excellent retention of consistency.

have a tendency to thin out under working conditions.

The pressure wear index, extreme pressure test, employed in this specification, has been difficult to interpret and to reproduce. However, products are available which have received approval.

High Temperature Grease

Some electrical accessories such as generator and magneto bearings operate at extremely high temperatures and yet do not require unusual low temperature performance. Specification AN-G-5a high temperature grease has been developed to withstand continuous operation at 300°F. in a high speed bearing for periods up to 300 hours. Some pressurized magnetos have presented another serious problem where the ozone atmosphere from the distributor or breaker housings came in contact with the grease in the bearings. The AN-G-5a grease stands up quite well under these oxidizing conditions. This grease is also recommended for wheel bearing lubrication in unusually hot weather where wheel hub temperatures are quite high. The AN-G-5a grease does not have good extreme low temperature properties, but is satisfactory at temperatures down to minus 20°F.

Graphite Grease

Graphite grease has been the accepted lubricant for starter gears ever since the first starters were introduced. Former military specifications permitted an ordinary garden variety of calcium soap grease with about 5% graphite. The range of usable temperatures of this grease is limited from about minus 20 to plus 175°F. This type of calcium soap grease is unstable at temperatures around 200°F. and may break down due to a disintegration of the grease structure.

The development of the AN-G-15 general purpose grease offered a solution to this problem. The Army decided to incorporate the AN-G-15 grease as a base with 5% graphite and have issued a new specification AAF 3607. This new graphite grease has substantially the same properties as the AN-G-15 grease and is better at both lower and higher temperatures than previously used products. The range of usable temperatures of the AAF 3607 is approximately minus 40°F. to 250°F.

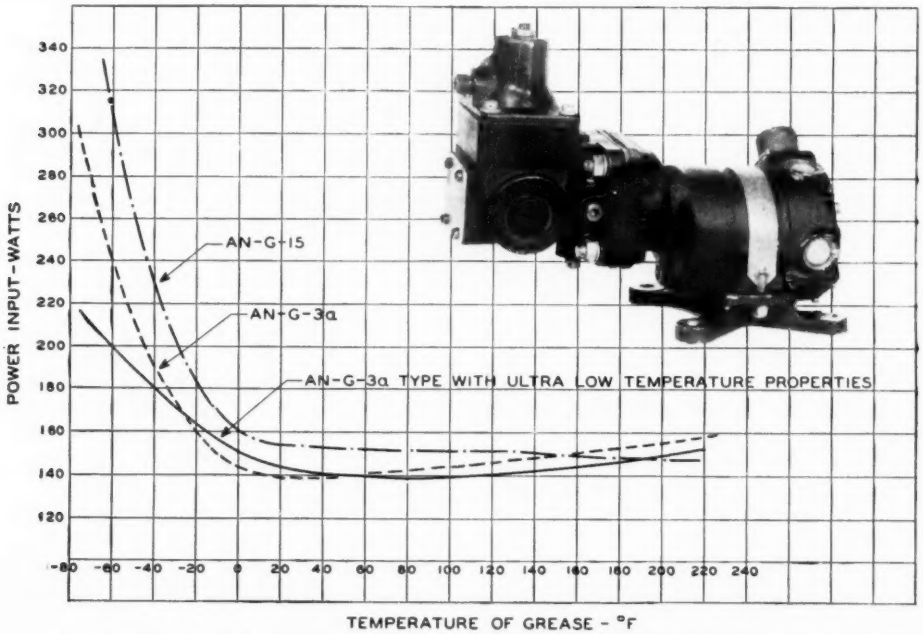


Fig. 3—Comparative performance of AN-G-15 and AN-G-3a type greases in Air Associates, Inc., motor driven fuel booster pump. Graph shows power input required for starting versus temperature, while insert shows the motor-driven pump.

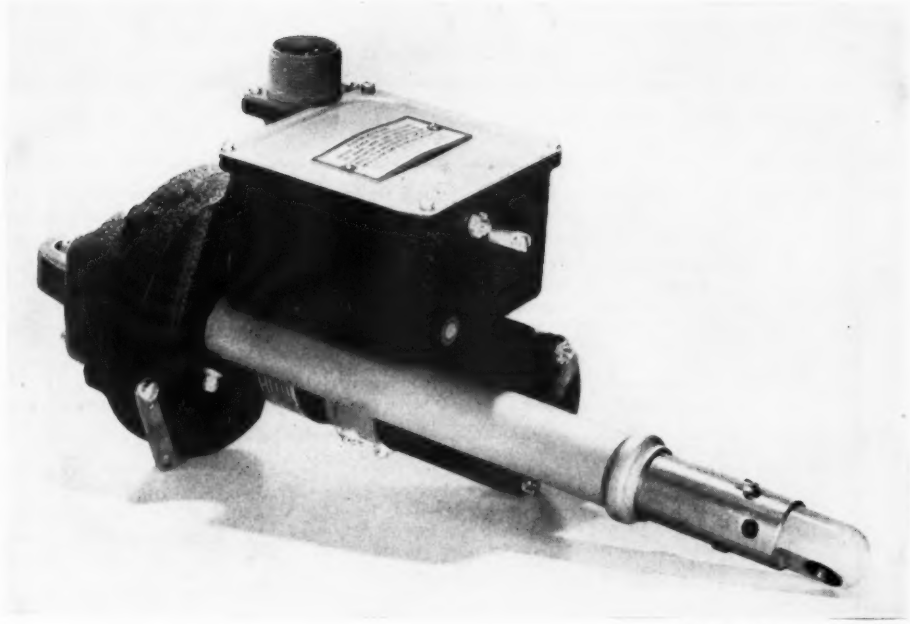
The improved graphite grease, AAF 3607, may find some additional uses such as for the lubrication of landing gear, screw jacks and flap drive screws. It may also be satisfactory for other exposed gears, and may eventually replace many of the uses of AN-G-10 grease.

AIRCRAFT SPECIALTY OILS

Excluding aircraft engine lubricating oils, there are three types of specialty oils for aircraft use:

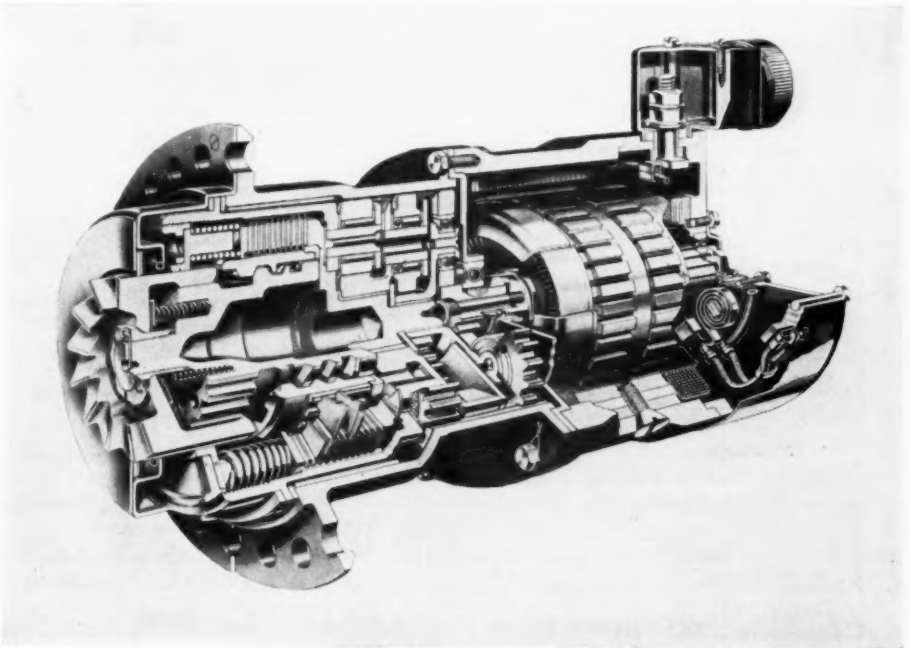
1 — Hydraulic oils.
2 — General purpose lubricating oils.
3 — Gear oils.

In each of these classifications, products have been



Courtesy Airesearch Mfg. Co.

Fig. 4—Screw jack actuator lubricated with AN-G-10 extreme pressure low temperature grease.



Courtesy Eclipse-Pioneer Division, Bendix Aviation Corporation

Fig. 5—Direct cranking electric starter. Motor bearings are prepacked with high temperature grease. Spec. AN-G-5a. Graphite grease, Spec. AN-G-6 or AAF-3607, is used on starter reduction gears and clutch assembly.

developed around military specifications and commercial needs to meet the particular requirements imposed by service.

Hydraulic Oils

Petroleum base hydraulic fluids are generally required for aircraft hydraulic systems of current de-

SUMMARY OF AIR

GREASES

Type of Grease	*Specification No.*	*Service Application*	*General Characteristics*
General Purpose	AN-G-15	Most antifriction bearings – both high and low speeds, gears. Routine maintenance requirements such as: Landing gear lubrication, wheel bearings, magneto gears, starter bearings, dynamotors, inverters, booster pump gears, propeller hubs, helicopter rotors. Usable temp. range: —40 to 250° F. Where sufficient torque available may be used down to —65° F.	Moderately good low temp. properties. Can be used at lower temp. if sufficient starting torque is available. Excellent stability up to 250° F. Does not liquefy in gears or high speed bearings — good shear resistance. Bearing endurance test over 1000 hrs. @ 10,000 rpm, 250° F. Resists water washing. Very low evaporation tendencies.
Low Temperature	AN-G-3a	Control Bearings — surface hinges, pulleys, flaps, actuating mechanisms, landing gear doors, cockpit controls, bell cranks, some lightly loaded slow speed gear boxes, flexible shafts. Usable temp. range: —65 to +175° F.	Good low temp. torque properties down to —65° F. Tendency to evaporate above 175° F. Unsatisfactory at high temp. May liquefy under working conditions — no provision made for shear resistance in specification.
Low Temperature, Low Evaporation Synthetic	AN-G-25	Same as above plus Gyro instrument bearings. Small electric motors — all temp. Usable temp. range: —65 to 250° F. Up to 300° F. for short periods.	Same low temp. torque as AN-G-3a greases. Evaporation tendency about 1/10 that of AN-G-3a greases. Good high temp. properties, 250° F. sustained or 300° F. short periods. Bearing endurance test over 1000 hrs. @ 10,000 rpm, 250° F. Satisfactory with Buna "N" rubber but causes swelling some other types. Good shear resistance — will not liquefy. Expensive. May replace AN-G-3a grease.
Low Temperature EP	AN-G-10	Slow speed gears, screws, worms, sprockets and chain where min. drag at low temp. is important and where higher load carrying ability is required compared with AN-G-3a. Usable temp. range: —65 to 175° F.	AN-G-3a grease plus EP additive. Good low temp. torque, higher load carrying capacity than AN-G-3a. Evaporates at high temp. Some have doubtful shear resistance.
High Temperature	AN-G-5a	High speed, high temp. bearings in generators, magnetos, other electrical equipment where low torque at low temp. not important. Splines of engine accessories. Wheel bearings — severe service. Usable temp. range: —20 to 300° F.	Exceptionally good high temp. stability. Bearing endurance test over 300 hrs. @ 10,000 rpm, 300° F. Withstands oxidizing atmosphere such as found in magnetos. Good shear resistance — does not liquefy. Water resistant. Limited low temp. performance.
Graphite	AN-G-6	Reduction gears — starters, retracting gears, chains. Not recommended for electrical equipment or antifriction bearings. Usable temp. range: —20 to 175° F.	AN-G-6 may contain ordinary calcium soap, resulting in a limited usable temp. range.
	AAF 3607	Usable temp. range: —40 to 250° F.	AAF 3607 will replace AN-G-6 and be made from AN-G-15 grease plus 5% graphite. More stable at high temp. and improved low temp. performance. Has general characteristics of AN-G-15.

RAFT LUBRICANTS

SPECIALTY OILS

Type of Oil	*Specification No.*	*Service Application*	*General Characteristics*
Hydraulic, Petroleum Base	AAF-3580D	Hydraulic systems and shock struts of commercial aircraft operating at medium altitudes. Usable temp. range: −50° F. to highest ambient.	Medium viscosity, high viscosity index. Suitable for med. temps.
	AN-VV-O-366b	Hydraulic systems and shock struts of military and high altitude commercial aircraft designed to use this product. Usable temp. range: −65° F. to highest ambient.	Low viscosity, very high viscosity index. Suitable for low temps. Requires adequate packing and seals.
General Purpose Lubricating	AN-O-6a	Plain bearings of instruments. General "oil can" applications requiring a very light, low temp. oil. Usable temp. range: −65° F. to highest ambient.	Good low temp. properties. Corrosion resistant. Evaporation tendencies may require frequent relubrication at high temps.
	SAE 10 or 20*	"Oil can" applications and general lubricant. Usable temp. range: 0° F. to highest ambient.	Readily available. Should be stable, well refined motor oil.
Gear Lubricating	AN-O-3, Medium and Light	Low temp. applications in Gear boxes and reduction gears designed for oil lubrication and operating at high loads. Usable temp. range: −40° F. to +225° F.	Good low temp. properties. High load carrying capacity due to EP additive.
	AN-O-8 Grade 1065	Gear boxes and reduction gears requiring straight mineral oil. Usable temp. range: 0° F. to +250° F.	Good stability. Non-corrosive. Satisfactory for moderately loaded gears.

*Viscosity classification only, not a specification.

sign and usage. Vegetable base oils were formerly used for some aircraft, however, principally in brake systems. Since packings and seals are designed specifically for use with either vegetable (natural rubber seals) or petroleum (synthetic, mineral oil-resistant seals) oils; the proper oil must always be used in a given system. In servicing aircraft for which no instructions are available, the use of vegetable base hydraulic fluid (castor oil plus alcohol) may be identified by the characteristic alcohol odor, whereas petroleum base fluid has only a faint mineral oil odor.

Two grades of petroleum base aircraft hydraulic oil are in use, Specification AAF-3580D type and Specification AN-VV-O-366b type. The former has been superseded for military use by the lower viscosity 366b product, which also has improved extreme low temperature properties, but the 3580D type is still required by a number of commercial aircraft.

In discussing the desirable properties of aircraft hydraulic oils, the viscosity must be low and must be affected as little as possible by the extremes in temperature at which the system operates. The pour point, or limiting temperature at which the oil remains fluid, must be exceptionally low to permit operation of the hydraulic units at the low-temperatures existing at high altitudes. Resistance to oxidation is also important, since oxidation products affect viscosity and also tend to promote corrosion. Other important properties are corrosion resistance and rubber-swelling tendencies, which for obvious reasons must be minimized.

General Purpose Lubricating Oils

Because of the ever increasing operational altitudes, the viscosity at low temperatures and the pour point are also important in aircraft instrument oils and general purpose or "oil can" lubricants. Corrosion preventive properties are necessary too, as protection against deterioration of equipment from corrosive atmospheres and moisture.

A new specification, AN-O-6a, has been written for such an oil for military applications. Some commercial aircraft will require this product for instruments and corrosion protection; however, others in normal service may be adequately protected from corrosion and friction with general household lubricants or well refined light motor oils, as recommended by the airframe manufacturer.

Gear Oils

Aircraft gear oils must remain fluid at low temperatures to provide low starting torque in accessory gear boxes, and must maintain a protective film on gear teeth at high temperatures. To provide high load carrying capacity, an extreme pressure agent is often compounded with oils of this type.

A product for this application, which at present is largely confined to military aircraft, is described by Specification AN-O-3, Low Temperature Gear Lubricating Oil. In commercial service not involving extremely low temperatures nor excessive loads, a number of different products have been used successfully. The most popular has been aircraft engine oil, Grade 1065 of Specification AN-O-8 or commercial grade 65.

LUBRICATION OF AIRFRAME COMPONENTS

Application of aircraft lubricants to airframe components is summarized on pages 38 and 39. This summary outlines the principal uses of the products listed, providing a basis for proper selection of lubricants. It is based on study of the design, operating conditions, service use, and other considerations involved.

In the case of the introduction of new equipment or of a demand for new lubricants brought about by new uses of existing equipment at higher loads or more extreme temperatures, aircraft manufacturers and oil companies have cooperated in the development of lubricants and lubrication technique. Lubrication problems arising in service have also been overcome, by both individual and joint action, as discussed in detail in the following section.

SERVICE PROBLEMS

Most aircraft lubrication problems can be classified into one or more of the following causes:

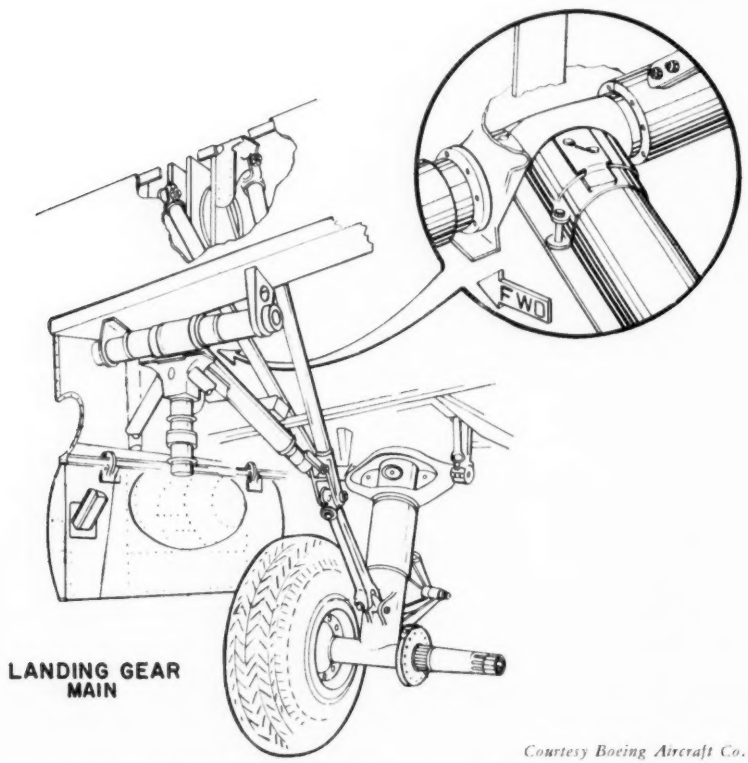
1 — Selection of the wrong type of lubricant.
2 — Unsatisfactory lubricant.
3 — Misapplication.
4 — Mechanical design.
5 — Foreign material.
6 — Maintenance practices.

Control bearings, at one time or another, have presented some of the most serious lubrication problems within the past few years. Perhaps each one of the above causes has played a part in control bearing lubrication.

During the early part of the war, a manufacturer of large bombers found that controls froze up, trim tabs wouldn't work, and bomb bay doors failed to open when flying at 30,000 feet. The grease used in these parts was unsatisfactory for the extremely low temperatures encountered. It was evident that the petroleum industry had to develop better low temperature greases to meet the high altitude requirements.

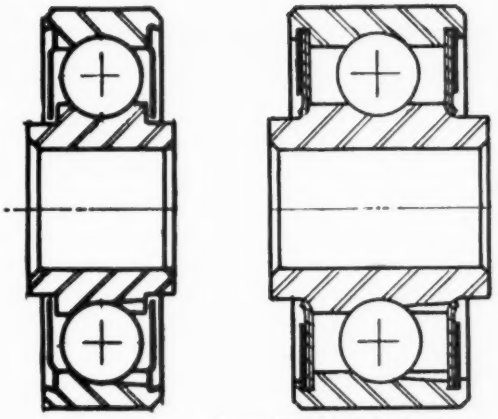
The question arose whether to develop greases for the average temperature found at 35,000 feet, which is −67°F., or whether it was necessary to have a grease which would function at the lowest temperatures encountered between 30,000 and 40,000 feet, approximately −100°F.

Some of the early experimental greases developed for −100°F. worked well at low temperatures, but evaporated badly at



Courtesy Boeing Aircraft Co.

Fig. 6—Main landing gear of Boeing B-29. Actuating screw requires AN-G-10 grease, pressure fittings require AN-G-3a, wheel bearings are lubricated by AN-G-15 grease, and AN-O-6a oil is applied to hinges, pins, and "oil can" points.



Courtesy The Fafnir Bearing Company

Fig. 7—Cross-sections of aircraft control bearings. Left, shielded type with metal shields, and right, bearing with removable rubber contact seals held in place by metal snap rings.

high temperatures. After three months' service in bombers based on the desert, with wing temperatures averaging 175°F. max., some of these early greases evaporated into a dry powdery substance. The reason for the excessive evaporation was traceable to the unusually low viscosity of the oil used in the grease.

Like many design compromises, the course followed by low temperature grease development was to compromise between the low temperature properties on one hand and the evaporation at high temperatures on the other. A higher viscosity oil was ultimately used, and one which was more closely fractionated to reduce the evaporation tendencies.

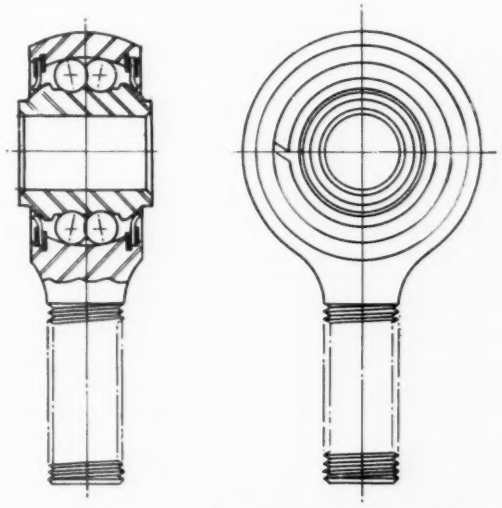
With the exception of some of the cases mentioned in the following, the better AN-G-3a low temperature greases have given reasonably satisfactory overall performance under all climatic and altitude conditions.

Strangely enough, corrosion of control bearings on the stockroom shelf has been the source of considerable concern to some aircraft companies. In one case recently, a prominent aircraft manufacturer had to reject 105 bearings out of a batch of 288, due to roughness, or a frozen condition. Some of these "rough" bearings were laid aside, and after two months' additional storage were locked solid. All of these bearings were the shielded type, where air or moisture are free to come in contact with the inside of the bearing. Some of these rough bearings were dismantled, and the grease was found to be in satisfactory condition. After cleaning the bearing parts, a very strange thing was discovered. Corrosion marks appeared wherever the balls and races had been in contact. In other words, corrosion occurred at each line of tangential contact. A similar condition is often found between the cams and cam followers in aircraft engines in storage, where engines were not wrapped in air-tight, moisture-proof bags, even though corrosion preventive oils were present.

Most cases of corrosion, according to one authority, are due to the fact that most of the lubricant is apparently squeezed out from between the two parts in tangential contact, over a period of time, leaving little protection against corrosion in the presence of moist air. There appears to be some merit to this explanation, because this type of corrosion does not occur in service, either in the case of the aircraft bearings or the aircraft engine parts. This form of corrosion also does not occur when bearings or engines are wrapped in air-tight, moisture-proof packages or containers, nor has it been discovered in the case of aircraft control bearings with the air-tight type of contact seals.

Corrosion or rusting of shielded aircraft bearings has presented a very serious problem in some classes of service. Some of the worst examples of corrosion have been found in transport planes operating across the Pacific. The self-aligning type of roller bearings on flap hinges became so badly corroded that many were completely frozen after short periods of service. These bearings were located in the slip stream where salt spray and coral dust from runways on these Pacific Islands created very corrosive conditions. The bearings were of the shielded type, not sealed, and there was nothing to prevent the propeller blast from driving this foreign material into the bearing. These conditions, incidentally, were bad enough to also affect chromium plate on shock struts.

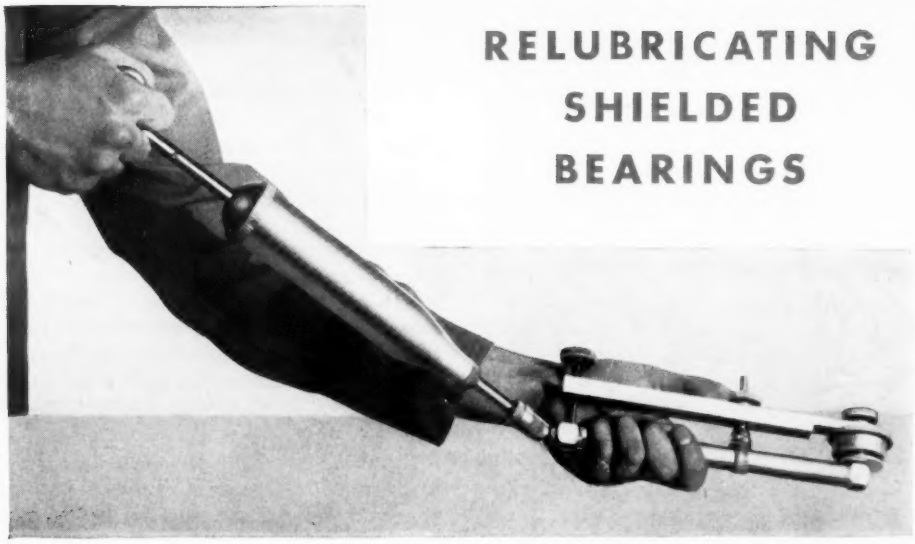
It is interesting to note that a manufacturer of large bombers, which were operating under iden-



Courtesy The Fafnir Bearing Company

Fig. 8—Aircraft control rod end equipped with latest type self-aligning, double-row bearing with contact seals.

RELUBRICATING SHIELDED BEARINGS

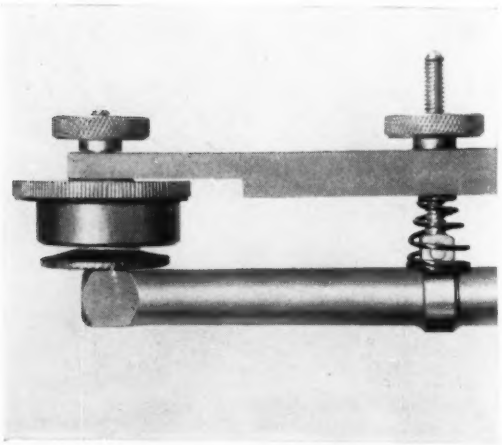


Photos courtesy of Alemite Division of Stewart-Warner Corp.

SPECIAL bearing lubricators, such as that shown in the accompanying figures, are available for relubrication of shielded bearings on control pulleys, bell cranks, rod ends and the like. A grease gun is used with the lubricator to pump new lubricant into the bearing, thereby forcing the old grease out the opposite side. A desirable feature of the use of lubricators of this type is the ability to relubricate many control bearings without removing them entirely from their assemblies.

Use of the lubricator is shown in the illustrations. Operating instructions issued by the manufacturer emphasize that the proper size cup and cone to fit the bearing should be used, and that the lubricator arms should be kept parallel by adjustment of the spring loaded fulcrum screw to enable proper seating of the cone on the bearing hub. Operation of the lubricator should be continued until all of the old grease has been forced out of the bearing by a complete charge of new lubricant.

The proper use of such relubricators is recommended by many manufacturers, and has resulted in improved control bearing lubrication when used in aircraft servicing.



Bearing in proper position for lubricating.

Lubricator ready to receive bearing.

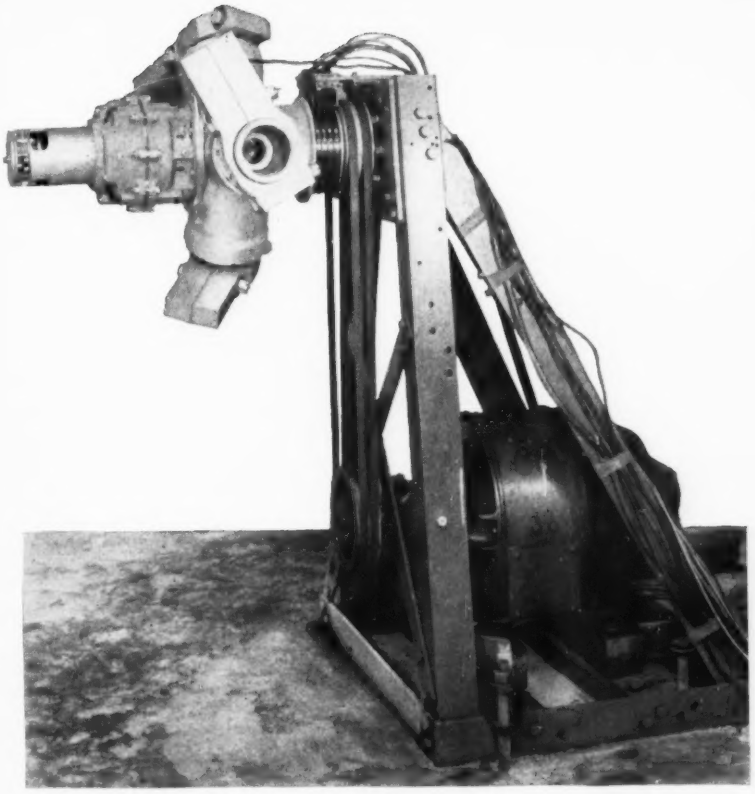


Fig. 9—Curtiss Electric Propeller Hub installed in laboratory cold room for testing lubricants at low temperatures. Note counterweights used in place of propeller blades.

tical conditions to the above transports, reported no difficulties with control bearings. This difference in performance is accounted for by the fact that all exposed bearings in these bombers had the contact type of rubber seals, and were not the shielded type.

The above bomber manufacturer reported having had a great deal of difficulty with control bearings during the early period of our North African operations. The control bearings, at that time, were only of the shielded type, which permitted the entrance of dust so prevalent in that area. After changing to the sealed type of bearings, all further difficulties of this nature ceased.

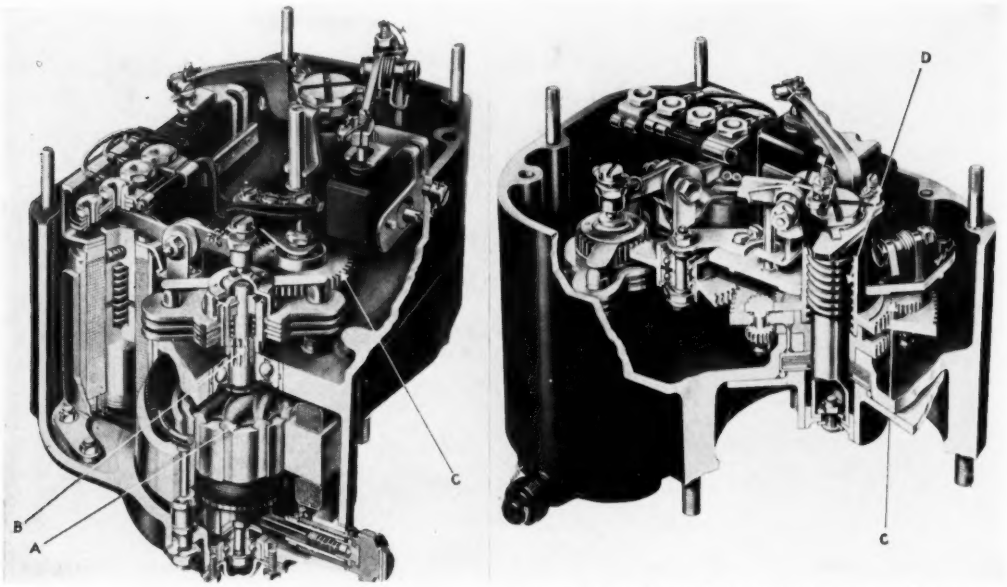
Many cases of corroded shielded type of aircraft bearings have been traced to maintenance practices. At the time of airplane major overhaul, steam cleaning has been employed, which was later revealed to remove low temperature greases from these bearings quite effectively when directed upon them. Removal of the protective coating of grease, and the entrance of water set up conditions favoring corrosion. Domestic airlines, who have not employed such drastic cleaning methods, have had much better success with the AN-G-3a greases in control bearings. It is not uncommon to find satisfactory results being obtained for periods of 4,000 hours between major overhauls without relubrication on domestic airlines.

Packing the shielded bearings full of grease, instead of using only a small quantity, has been found very helpful in reducing the breathing action and entrance of moisture into the bearing.

While some cases of frozen control bearings may be traced to the grease, nevertheless, there are other cases of freezing which can be traced to freezing of moisture or water within the bearing. The obvious solution to the latter problem is the contact type of seal.

Magneto gear boxes presented an interesting example of shear stability of a grease, or tendency to thin out or work down into a liquid. In a certain magneto a grease with poor shear stability liquefied in less than 30 minutes, whereas a more stable grease showed no change after 100 hours. A grease which tends to liquefy in a magneto gear box is very undesirable because some of the lubricant may leak down into the breaker housing, causing failure of breaker points. The new AN-G-15 general purpose grease has a provision to insure against this undesirable working-down tendency. This type of grease is showing very good performance in these gear boxes.

Another interesting lubrication problem arose in connection with the electric propeller governor control head, which operates over an extremely wide range of temperatures. Greases which stiffen excessively at low temperatures burn out the small motor actuating the unit, and the same lubricant must also withstand temperatures of well over 200°F. Neither the low temperature nor the general purpose greases have been able to satisfy the wide range of temperature. The new low temperature, low evaporation, synthetic grease, AN-G-25, has proven satisfactory for this exacting condition, comprehensive laboratory and service tests having been run by the manufacturer of the unit.



Courtesy Eclipse-Pioneer Division, Bendix Aviation Corporation

Fig. 10—Electric propeller governor control head, showing (A) 1/50 H.P. electric motor which powers the unit, (B) clutch spline, (C) gear train and (D) screw jack actuator requiring AN-G-25 grease.

SUMMARY

Only in the last few years has the lubrication of air-frame and engine accessories presented a need for special lubricants to operate over a wider range of temperatures. These new lubricants are the result of the combined efforts of the aviation and petroleum industries stimulated by valuable suggestions from both the Army and the Navy as summarized on pages 38 and 39. The story of these developments is by no means finished, and must necessarily continue in the future.

The lubricants now available appear to be well suited for aircraft of the present and immediate future, assuring dependable lubrication under all atmospheric and flight conditions. This performance may be attributed to the cooperative efforts of aircraft designers, bearing manufacturers, and lubricant suppliers, all of whom were necessary to reach the best solution.

The new lubricants, together with improved maintenance practices, will result in benefits to operators in the form of improved performance, lower maintenance costs, and fewer products to handle a given job.

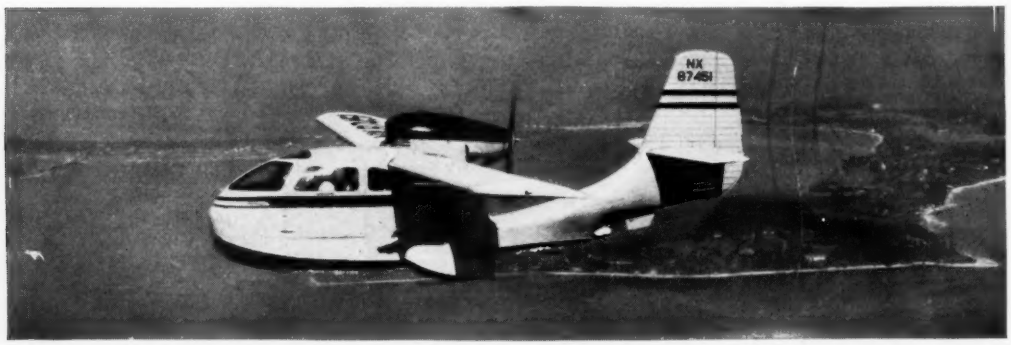


Fig. 11—The Republic Seabee — a four-place, all-metal amphibian in the personal plane class.

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FOR AIRFRAME AND ENGINE ACCESSORIES

APPLICATION	TEXACO PRODUCT	TYPE
Most antifriction bearings, landing gear, wheel bearings, magneto gears, starter bearings, dynamotors, inverters, propeller hubs, helicopter rotors, routine maintenance requirements.	Regal Starfak Special	General Purpose Grease Spec. AN-G-15
Control bearings, hinges, pulleys, flaps, actuating mechanisms, landing gear doors, bell cranks, flexible shafts.	LOW-TEMP Grease 67	Low Temperature Grease Spec. AN-G-3a
Same as above plus gyro instrument bearings, small electric motors — all temperatures.	UNI-TEMP Grease	Low Temperature, Low Evaporation Synthetic Grease Spec. AN-G-25
Slow speed gears, screws, worms, sprockets and chains where minimum drag at low temperatures and high load carrying capacity are required.	LOW-TEMP Grease 100 EP	Low Temperature EP Grease Spec. AN-G-10
High speed, high temperature bearings in generators, magnetos, and other electrical equipment. Splines of engine accessories. Wheel bearings in severe service.	HIGH-TEMP Grease	High Temperature Grease Spec. AN-G-5a
Reduction gears of starters, retracting gears, chains.	Aircraft Starter Grease	Graphite Grease Spec. AAF-3607
Hydraulic systems and shock struts of commercial aircraft operating at medium altitudes.	Aircraft Hydraulic Oil A	Hydraulic Oil Spec. AAF-3580D
Hydraulic systems and shock struts of military and high altitude commercial aircraft designed to use this product.	Aircraft Hydraulic Oil AA	Hydraulic Oil Spec. AN-VV-O-366b
Plain bearings of instruments. General "oil can" use requiring a very light, low temperature oil.	Texaco TL-727 Oil	General Purpose Lubricating Oil Spec. AN-O-6a
"Oil Can" and general lubrication applications.	Havoline Motor Oil SAE 10 or SAE 20	General Purpose Lubricating Oil SAE 10 or 20
Low temperature applications in gear boxes and reduction gears designed for oil lubrication and operating at high loads.	Medium TL-875 Light TL-874	Low Temperature Gear Lubricating Oil Spec. AN-O-3, Medium and Light
Gear boxes and reduction gears requiring straight mineral oil.	Texaco 1065 Oil	Lubricating Oil Spec. AN-O-8

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